E-309

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PROGRESS REPORT OF EXPERIMENTS ON THE CONTROL OF CABBAGE WORMS

Division of Truck Crop and Garden Insects,

Bureau of Entomology, U. S. Department of Agriculture

INTRODUCTION

In the fall of 1932 the Bureau of Entomology began a series of experiments to determine, for various species of cabbage worms, methods of control which would not leave injurious insecticidal residues. The results of these preliminary tests do not justify making general recommendations at the present time. Because of the interest in insecticidal residues that may remain on cabbage and similar crops, the results of the experiments are here reported for the benefit of others interested in these problems. By informing other workers of the nature and scope of the study and the more important results obtained thus far, it is hoped to hasten the solution of the problem of cabbage worm control and the elimination of poisonous residues. This review, prepared by P. N. Annand and C. A. Weigel, is based on results of experiments conducted at Chadbourn, N. C., and Charleston, S. C., by W. A. Thomas, W. J. Reid, and L. B. Reed; at Baton Rouge by C. E. Smith and P. K. Harrison; and at Columbus, Ohio, by N. F. Howard and R. H. Davidson, during the season of 1932-1933.

ARSENICAL RESIDUES ON CABBAGE RESULTING FROM APPLICATION OF PARIS GREEN, LEAD ARSENATE, AND CALCIUM ARSENATE

A series of experiments were conducted to obtain definite information on (1) the number of applications which could be applied in a regular spray schedule without exceeding the legal tolerance of 0.01 grain of arsenic trioxide per pound, and (2) to determine the last safe date for arsenical applications in the areas under investigation. These experiments consisted of a series of plots at Charleston, S. C., and Baton Rouge, La., the plots of each series being subjected to a varying number of applications. One plot was excluded from treatment at each 10 or 14 day interval, depending on the time of the year and the speed of development of the cabbage plants, until 10 to 14 days before harvesting. Thus, at harvest time each series included plots which had received 1, 2, 3, and up to the maximum number of applications made (see Table 2). Analyses were made at harvest time of all plots to determine the effect of number of applications on the occurrence of arsenical residues. In these series an opportunity was also given to determine how close to harvest time arsenical applications could safely be made.

Baton Rouge, La. In the work at Baton Rouge, La., five series of experiments were conducted, two in the fall and winter, and three during the spring, on the Copenhagen Market Variety. The first and second series consisted of 10 and 12 plots, respectively, and the last three of 20 plots each, a plot being 1/20 acre in area. The arsenical mixtures tested were Paris green and lime (1-10), lead arsenate and lime (1-5), and calcium arsenate and lime (1-5). Lead arsenate was used in these and other experiments previous to the placing of definite limitations on lead residues. In later experiments emphasis was placed on Paris green and calcium arsenate.

The treatments were started about 10 days after transplanting, repeated at 10-day intervals, and discontinued 10 days before maturity. The area treated with each arsenical mixture was reduced by one plot for each consecutive application. The maximum number of applications per plot ranged from 6 to 8. It was planned to apply the calcium arsenate and lead arsenate at the rate of 4 pounds per acre and Paris green at the rate of 1 1/2 pounds per acre per application. The amount actually applied varied considerably, however, due to a large extent to the size of the plants and weather conditions. While the plants were small, one half or less of the above dosage gave excellent coverage. The average amounts of poisons (exclusive of the lime) applied per acre per application throughout the Baton Rouge tests were Paris green 1.24, lead arsenate 3.13, and calcium arsenate 2.47 pounds. Rotary hand guns were used in applying the dust. The first three or four applications, while the plants were small, were made by passing once to the row, and for all later ones by passing twice to the row, with the delivery tube directed nearly horizontally on both sides. In this way a much superior coverage to the undersides of the leaves was obtained. This was essential where the looper was the major species involved. Calm weather was selected for making the application whenever possible.

Barriers made of 36-42 inch cloth were used to reduce drifting of the dusts, but they were not entirely effective.

The effectiveness of the poisons was determined by counting the worms in a certain number of plants (usually 25) selected at random on each plot. The counts were made about five days before and after applications.

The worm control obtained in these experiments was unsatisfactory even in the plots receiving the maximum number of applications. This was due in part to unfavorable weather. The worm infestations were light for the season as a whole. On only 16 out of the 72 plots did the control amount to 50 percent or over and the average for all plots was considerably less than 50 percent. Calcium arsenate was inferior to Paris green and lead arsenate, which were about equally effective.

Samples for residue determination consisted of 10 mature heads selected at random on each plot and trimmed according to the specifications for U. S. No. 1 grade. Opposite quarters of each head were used for analysis. Analyses were made by Mr. J. L. Farr of the Louisiana Experiment Station, using the same methods employed by the Bureau of Chemistry and Soils in similar determinations.

In Table 1 the results of one of the series conducted at Baton Rouge is given. The results here indicated are typical of similar experiments conducted at this station.

Table 1.- Experiments at Baton Rouge on the Copenhagen Market variety, March 15 to May 15, 1933.

Plot No.	Applications: Number	From last application to time of sampling: Days	From last application to time of sampling: Ins. rainfall	Total of arsenical applications per acre: Pounds	Worm Control: Percent	Amount of As_2O_3 residue per pound: Grain
Calcium arsenate and lime (1-5)						
1	0	61	11.09	0.00	00.0	0.0014
2	1	61	11.09	1.29	31.3	0.0011
3	2	49	9.10	3.22	46.4	0.0009
4	3	42	8.63	6.91	24.1	0.0009
5	4	33	6.34	10.52	58.9	0.0009
6	5	25	4.26	14.30	31.03	0.0014
7	6	17	1.22	18.30	51.7	0.0022
8	7	10	0.00	20.80	36.0	0.0162
9	7	10	0.00	20.80	54.2	0.0017
Paris green and lime (1-10)						
11	0	61	11.09	0.00	00.0	0.0019
12	1	61	11.09	.93	28.0	0.0016
13	2	49	9.10	2.11	10.3	0.0019
14	3	42	8.63	4.19	46.8	0.0028
15	4	33	6.34	6.63	48.9	0.0016
16	5	25	4.26	7.84	7.8	0.0019
17	6	17	1.22	10.05	44.6	0.0046
18	7	10	0.00	12.55	39.0	0.0134
19	7	10	0.00	12.55	65.2	0.0092

Charleston, S. C. At the Charleston, S. C., station eight series were conducted during the fall and spring season on Charleston Wakefield variety. Lead arsenate and lime (1-5) and Paris green and lime (1-10) were used. The desired rate of application was 4 pounds of lead arsenate and 1 1/2 pounds of Paris green per acre per application. The actual amount was subject to variation, as indicated above. The number of applications per plot varied in each series from 1 to 10 or as many as could be made up to 10 to 14 days before harvest.

As in the Baton Rouge experiments, the area treated with each arsenical mixture was reduced by one plot for each consecutive application. The interval between applications was 10 days, except that in the winter months, when plant growth was slower, the interval was 14 days. Applications were made early in the morning with a rotary duster. Samples for arsenical residue analysis were taken at the same time for all plots after the last application of a given experiment. The samples were taken 10 to 14 days after the last application on the plot receiving the maximum number, the time depending on the interval which had been allowed between the different applications. It was finally determined that 10 heads from each plot were sufficient for chemical analysis, and the samples were reduced to this number for the later experiments. For the last four experiments

only the opposite quarters of the heads were used. Analyses for arsenic were made by the Bureau of Chemistry and Soils. A detailed account of one of the experiments is here presented in order to give a clear picture of the procedure and method followed.

The insecticide used in this experiment was Paris green and hydrated lime dust (1-10 by weight), the rate of application being 1 1/2 pounds of Paris green per acre per application, and the period between applications was 10 days. Table 2 gives the arrangement of a typical series of plots, with the dates and number of applications.

In Table 3 a summary of the data obtained on this experiment is presented. Table 4 presents data on the relation between the number of applications and the time of the last application before harvest time to the legal tolerance. This summarizes the data from the eight series.

Table 2.- Chart showing arrangement of a typical series of plots at Charleston, season of 1932-1933, giving the dates and number of applications of Paris green and lime (1-10).

EAST

Rows		
1	Plot 1	Plot 6
2	Poisoned:	Poisoned:
3	1. Jan. 20	1. Jan. 20
4		2. Jan. 31
5		3. Feb. 13
6		4. Feb. 22
7		5. Mar. 3
8		6. Mar. 13
9	Plot 2	Plot 7
10	Poisoned:	Poisoned:
11	1. Jan. 20	1. Jan. 20
12	2. Jan. 31	2. Jan. 31
13		3. Feb. 13
14		4. Feb. 22
15		5. Mar. 3
16		6. Mar. 13
17		7. Mar. 23
18	Plot 3	Plot 8
19	Poisoned:	Poisoned:
20	1. Jan. 20	1. Jan. 20
21	2. Jan. 31	2. Jan. 31
22	3. Feb. 13	3. Feb. 13
23		4. Feb. 22
24		5. Mar. 3
25		6. Mar. 13
26		7. Mar. 23
27		8. Mar. 31
28	Plot 4	Plot 9
29	Poisoned:	Poisoned:
30	1. Jan. 20	1. Jan. 20
31	2. Jan. 31	2. Jan. 31
32	3. Feb. 13	3. Feb. 13
33	4. Feb. 22	4. Feb. 22
		5. Mar. 3
		6. Mar. 13
		7. Mar. 23
		8. Mar. 31
		9. Apr. 10
	Plot 5	Plot 10
	Poisoned:	Poisoned:
	1. Jan. 20	1. Jan. 20
	2. Jan. 31	2. Jan. 31
	3. Feb. 13	3. Feb. 13
	4. Feb. 22	4. Feb. 22
	5. Mar. 3	5. Mar. 3
		6. Mar. 13
		7. Mar. 23
		8. Mar. 31
		9. Apr. 10
		10. Apr. 20
	Plot 11a	Plot 11b
	Unpoisoned check	Unpoisoned check

Date of sampling, April 30.
Note: Dusting dates were irregular because of unfavorable weather conditions.

Table 3. -- Summary of data obtained at Charleston on experiment outlined in Table 2.

Plot	Total applications	Insecticide used per acre*	Rainfall from application to sampling	Worms per plant (average of 25 plants)	Exposed leaves per plant at final application (average of 25 plants)	Plants having notched leaf on marketed portion	As_2O_3 per pound (Average of 10 heads)
		Pounds	Inches			Per Cent	Grain
1	1	1.74	11.31	0.048	6.0	0.0	0.0004
2	2	1.50	9.73	0.112	6.8	0.0	0.0004
3	3	1.70	5.00	0.092	8.3	0.0	0.0004
4	4	1.74	3.69	0.052	10.3	0.0	0.0004
5	5	1.77	3.69	0.256	12.0	0.0	0.0004
6	6	1.81	2.80	0.168	12.8	0.0	0.0004
7	7	1.95	2.47	0.103	15.3	30.0	0.0004
8	8	1.95	2.47	0.104	17.4	70.0	0.0021
9	9	1.95	1.76	0.140	18.0	100.0	0.0042
10	10	1.95	1.14	0.120	20.0	100.0	0.0162
11	Unpoisoned	----	----	0.192	----	-----	------

* The rate desired was 1-1/2 pounds per acre. The actual application varied from this, as indicated, due to variation in conditions at the time of application.

Table 4.- Summary of data on arsenical residue experiments on cabbage, season of 1932-33, at Charleston, S. C., showing relation of number of applications and the time of last application before harvest to legal tolerance limit.

Lead arsenate and hydrated lime (1-5)			Paris green and hydrated lime (1-10)		
	Tolerance of 0.01 grain per pound exceeded			Tolerance of 0.01 grain per pound exceeded	
Expt.No.	At application No.	Number of days applied before harvest	Expt.No.	At application No.	Number of days applied before harvest
Fall crop					
2	7	20	1	7	20
3	8	20	4	8	20
Spring crop					
5	7	14	6	7	14
7	10	10	8	10	10

Because of the unusually light insect infestations existing throughout the period of these experiments, data on the degree of worm control from the arsenical applications are not conclusive. The rainfall during the period was above normal and resulted in rather low quantities of arsenical residue being present on the plants at harvest, even in case of the spring experiments when the plots received as many as ten applications.

Summary of results obtained. Analysis of these experiments at Baton Rouge and Charleston indicate that Paris green and lime (1-10), lead arsenate and lime (1-5), or calcium arsenate and lime (1-5) can be applied to cabbage, under Louisiana and Carolina conditions, regardless of the number of applications, up to 20 days of maturity without leaving a residue exceeding the legal tolerance. In South Carolina a maximum of 9 applications was possible, according to the results indicated in some of the experiments conducted during a period of heavy rainfall. Apparently, one of the most important factors is the time elapsing between the last application and the date of harvest rather than the total number of applications made. The importance of rainfall has not been determined, but it undoubtedly plays an important part, as applications during wet periods were made closer to harvest without exceeding the tolerance. The amounts of residue resulting from Paris green, lead arsenate, and calcium arsenate were about the same at harvest when equal numbers of applications were made.

THE RELATION OF PLANT DEVELOPMENT TO ARSENICAL RESIDUES

Baton Rouge, La. To determine the stage of growth when the first foliage is produced which is exposed and subject to residue and which remains on the harvested product, the youngest exposed leaves were marked at different stages of maturity. In the last three series the youngest exposed leaves on 10 plants were marked by cutting a V-shaped notch in the tips at the time each plot received its last application. Leaf counts were also made. From these data it

was found that leaves which became exposed 40 days before maturity in the fall and 20 days before maturity in the spring were trimmed off when the cabbage was cut as required for U. S. No. 1 grade. The period would possibly be prolonged somewhat for cabbage maturing during the colder months. Most of the observations were made on the variety Copenhagen Market. The period was a little longer proportionally on the Charleston Wakefield variety. Notching of the leaves as a means of marking was not entirely satisfactory, especially when the plants were young and when severe worm infestation occurred.

Charleston, S. C. Similar experiments were conducted at Charleston in which information was obtained on the stage and age of the plants of certain of the plots at the time they received the last arsenical application by recording the following: (1) The number of visible leaves on 25 plants selected at random from the plot. (2) The appearance of the entire plot and of a representative plant, recorded by photographing the plant with a linear measure beside it. (3) The presence of leaves on the harvested heads previously marked by cutting a V-shaped notch in the margin of the innermost leaf, at the time of the last application, of 10 plants of the plot. The position of these marked leaves was noted at harvest, particularly as to whether the notched leaf was present after the head had been trimmed for market. (See Table 3.)

At both Charleston and Baton Rouge these studies would seem to partially explain why the amount of arsenical residue remains low on the plants receiving arsenical applications only in the early stages of their growth and then suddenly increases in late season applications. All foliage of the plant that would be likely to receive any of an insecticide applied during the first half of the growth period is shed from the plant before harvest. It was only when the leaves that were on the plant at the time of the final application of arsenicals were present in the marketed product that the arsenical residue exceeded the tolerance.

Columbus, Ohio. Observations were made at Columbus to determine the number of days from transplanting to heading and the time of head formation. Golden Acre and the Marion Market varieties of cabbage were used. The summarized data for the Golden Acre cabbage is as follows:

Average number days from transplanting to heading	64.5
Maximum " " " " " "	69
Minimum " " " " " "	60
Average number days from transplanting to harvest	81
Maximum " " " " " "	90
Minimum " " " " " "	72
Average number days from heading to harvest	16.5
Maximum " " " " " "	21
Minimum " " " " " "	12

In the case of the Marion Market variety the average number of days from transplanting to heading was 68.1, with a range of from 60 days to 81 days.

THE CONTROL OF CABBAGE WORMS BY ARSENICAL AND NONARSENICAL DUSTS

The purpose of the studies reported herein was to find a suitable nonpoisonous substitute for the arsenicals for use on cabbage and other leafy vegetables in order to avoid the possibility of the marketed product carrying poisonous residue. These tests were conducted during the spring of 1933 at the Chadbourn, N. C., Charleston, S. C., and Baton Rouge, La., laboratories. The materials used in these tests were pyrethrum, derris, and hellebore dusts. For comparison with arsenicals, Paris green and lime and calcium arsenate were included. The applications were made with standard makes of hand dusters.

Owing to the large amount of detailed data accumulated in these tests, only a summary of the results will be presented here in order to give an idea of the scope of the work.

Charleston, S. C., and Chadbourn, N. C. The data here presented were compiled from the records of the third and fourth dustings of an experiment designated as No. 4 of the Charleston series and of the second and third dustings of experiment No. 1 at Chadbourn. The results of the earlier dustings at both of these places are not included because of the extremely small worm population existing at that time. A record was made of the weather conditions at the time of application.

In Table 5 is given a comparative summary of the control data, by species, of the Charleston and Chadbourn tests, together with the actual cost of materials per acre.

The insect population averaged 9.80 larvae per plant at Charleston and 2.24 at Chadbourn, divided between the species as follows:

Species	Charleston, S.C.	Chadbourn, N.C.
Loopers	80.3 percent	67.3 percent
Diamond backs	14.1 percent	25.1 percent
Common cabbage worms . . .	5.6 percent	7.6 percent

The analyses made by the Bureau of Chemistry and Soils of the organic material gave the following results:

Derris used at Charleston, 5.4 percent rotenone, with a total of 22.7 percent carbon tetrachloride extract.

Derris used at Chadbourn, 4.9 percent rotenone, with a total extract of 18.8 percent.

Derris used at Baton Rouge, 4.7 percent rotenone, total extract 18.8 percent.

Pyrethrum used at Charleston, 0.24 percent pyrethrin I.

Pyrethrum used at Chadbourn, 0.31 percent pyrethrin I.

Pyrethrum used at Baton Rouge, 0.34 percent pyrethrin I.

Hellebore, 0.88 percent total alkaloids.

CORRECTION

E-309. Progress Report of Experiments on the Control of Cabbage Worms, Division of Truck Crop and Garden Insects, Bureau of Entomology, U. S. Department of Agriculture.

Page 8 - line 2 from bottom should read:

"Pyrethrum used at Baton Rouge, 0.34 percent pyrethrin I

Table 5.-- Comparative summary of control data, by species, at Charleston, S. C., and Chadbourn, N.C.

Insecticide	Average rate of application of dusts per acre		Reduction in number of worms per plant as compared with the undusted plots								Actual cost of materials per acre	
			Loopers		Diamond backs		Com. cab - bage worms		All 3 species		Charleston, S.C.	Chadbourn N.C.
	S.C.	N.C.	S.C.	N.C.	S.C.	N.C.	S.C.	N.C.	S.C.	N.C.		
	lbs.	lbs.	%	%	%	%	%	%	%	%		
Derris	11	10	85	78	92	88	100	100	87	82	$3.41	$3.10
Derris	13	14	82	87	91	91	97	100	84	89	4.03	4.34
Derris and tobacco (1-1)	11	12	80	89	90	87	92	100	82	89	1.79	1.95
Derris and tobacco (1-1)	17	14	80	77	97	86	100	100	84	85	2.76	2.28
Pyrethrum	11	12	75	68	35	63	75	85	61	68	2.31	2.52
Pyrethrum	15	15	69	62	36	77	88	85	66	67	3.15	3.15
Pyrethrum and tobacco (1-1)	9	12	66	52	62	50	78	73	66	53	1.01	1.35
Pyrethrum and tobacco (1-1)	15	17	78	53	72	43	84	95	72	53	1.69	1.91
Hellebore	9	15	24	38	50	48	1	18	35	18	1.26	2.10
Hellebore	17	16	34	17	54	13	60	2	39	2	2.39	2.24
Hellebore and tobacco (1-1)	12	15	43	36	68	44	50	6	47	6	0.93	1.16
Hellebore and tobacco (1-1)	15	20	58	28	82	39	90	52	52	52	1.16	1.55
Lead arsenate and lime (1-5.4)		19		22		-10		-2		12		0.46
Calcium arsenate (undiluted)	11		33		79		65		42		0.66	
Calcium arsenate (undiluted)	17		48		87		73		56		0.99	
Calcium arsenate and lime (1-7)		20		24		12		75		25		0.27
Paris green and lime (1-10)	17		26		15		75		26		0.57	
Paris green and lime (1-10)	22		33		20		56		34		0.74	
Paris green and lime (1-9)		21		43		63		83		51		0.76
Tobacco dust	9		17		21		7		14		0.14	
Tobacco dust	11	16	53	25	44	36	-15	-7	30	25	0.17	0.24

Note: Cost of materials is based on actual rate per acre per application, figured on f.o.b. retail prices in 100 lb. lots.

An experiment was also conducted to determine the relative effectiveness of morning and night applications of derris, pyrethrum, and hellebore. Each insecticide was mixed with equal parts of tobacco dust. Each plot consisted of five 80-foot rows of cabbage set out on April 12. An attempt was made to apply only 15 pounds, but this amount was exceeded in all cases. (See Table 6.)

Extreme difficulty was experienced in getting a uniform rate of application on the plots, even when the setting of the gun remained the same. There is a very great difference in the rate of flow through the gun of the various materials, and each machine had to be calibrated for each material. The speed of the operator and the speed of the gun must be carefully watched to secure any degree of uniformity.

Infestation counts were made three days after dusting by examining 25 plants in the center row of each plot. There was an average of 1.91 worms per undusted plant. These consisted of 64 percent cabbage loopers, 27 percent diamond-back moth larvae, and 9 percent common cabbage worms. In Table 6 are presented the comparative results of morning and evening dusting applications for the tests at Chadbourn, N. C.

Table 6.- Comparative results of morning and evening applications, Chadbourn, N. C.

Insecticide	Time of application	Actual rate of application per acre*	Cost of materials per acre	Reduction in number of worms per plant as compared with undusted plots			
				Loopers	Diamond-back	Com. cab. worms	All 3 species
		Pounds		Percent	Percent	Percent	Percent
Derris & tobacco	P.M.	17	$2.76	74	100	100	83
" "	A.M.	16	2.60	46	69	100	57
Pyrethrum & tob.	P.M.	16	1.80	79	65	100	77
" "	A.M.	17	1.91	25	-6	67	20
Hellebore & tob.	P.M.	16	1.24	33	18	56	31
" "	A.M.	17	1.32	59	53	33	55

*Fifteen pounds per acre was the desired rate.

Baton Rouge, La. These field experiments were similar in many respects to those conducted at Charleston and Chadbourn. The nonarsenicals tested were derris, pyrethrum, and hellebore powders. Tobacco dust (0.5 percent nicotine) and finely ground dusting sulphur were used as diluents. The plots ranged in size from about 1/20 to 1/4 acre in area, and the plants were of maturing size. The procedure was much the same as that described under the arsenical residue tests. The dusts were applied with a rotary hand duster by passing twice to the row —once on both sides. The amounts of the dust mixtures applied ranged from about 3 to 20 pounds per acre per application. The cabbage looper constituted a large percentage of the worm population, and the larvae of the diamond-back moth nearly all of the remainder.

In series 1 the cabbage looper was the principal species involved. Mr. C. O. Hopkins, Extension Entomologist, assisted in two of these series. Dry hot weather and almost continuous high south winds prevailed during the first part of the period when the eggs for the destructive brood were laid. Worm population counts, on a certain number of plants selected at random over the plots, were made

just prior to the dusting and again 24 hours afterward. The cabbage was of the variety Copenhagen Market and the plants were large and maturing. Applications were made between 6 and 8:30 p.m., automobile headlights being used for illumination after dusk. The plots were 1/20 acre in size.

The following materials were used:

Pyrethrum and sulphur..... (1-2)

Pyrethrum, tobacco dust, and sulphur..... (1-1-1)

Pyrethrum and tobacco dust..... (1-1)

Pyrethrum, tobacco dust, and sulphur..... (1-4-5)

Derris and tobacco dust..... (1-1)

Derris and tobacco dust..... (1-3)

Derris and sulphur..... (1-3)

Derris, tobacco dust, and sulphur..... (1-4-5)

All of the stronger pyrethrum dusts gave very satisfactory results (ranging from 70 to 85 percent) when the dosage was 10 pounds or over per acre per application. The toxic effects seemed to have been completed before the end of a 24-hour period, whereas none of the derris mixtures gave satisfactory kills within the 24 hours.

In series 2 derris was used undiluted and great care was taken to obtain as nearly equal dosages as the textures of the various preparations would permit. Also, one half of the plots (1/20 acre) were treated in late afternoon, the other in the late forenoon, i.e., from 5 to 7 p.m. and 9:30 to 11:30 a.m. Worm population counts were made as in series 1, plus an additional count 6 days after treatment.

The dust mixtures used were as follows:

Derris (undiluted).....

Derris and tobacco..... (1-1)

Derris and sulphur..... (1-1)

Hellebore and sulphur..... (1-2)

Pyrethrum, tobacco dust, and sulphur..... (1-2-3)

Pyrethrum, tobacco dust, and sulphur..... (1-1-1)

Pyrethrum and sulphur..... (1-2)

Pyrethrum and tobacco dust..... (1-1)

The derris dusts gave excellent kills, the undiluted being slightly better than the tobacco dust mixture, and the latter slightly better than the sulphur mixture. The results of the afternoon application were slightly better than those of the forenoon application. The hellebore dust, though somewhat toxic, was less effective in the afternoon treatment and considerably inferior to derris and pyrethrum. The counts 6 days later indicated some residual value for hellebore. The stronger pyrethrum dusts gave good controls, and the weaker ones killed in proportion to their pyrethrin content. Later afternoon applications were about 50 percent more effective than those applied during the forenoon. Only young larvae were killed by the forenoon treatments. As for the comparative efficiency of the one-way and two-way applications with one mixture, the kill for the one-way application was 66 percent in contrast with 88 percent for the two-way application.

The worm counts indicated a greater comparative residual value for derris than pyrethrum, as is evident from the following data obtained in counts made 24 hours and 6 days, respectively, after applying the dusts.

Materials	Time applied	Total larvae	Larvae at end of -- 24 hours	Larvae at end of -- 6 days
Derris (undiluted).....	Afternoon	526	27	7
Derris and tobacco dust.....	"	224	19	6
Derris and sulphur.....	"	192	24	1
Pyrethrum and tobacco dust (1-1).	"	130	21	48
Pyrethrum and tobacco dust (1-1).	Forenoon	115	53	22

In series 3 the purpose was to determine the relative effectiveness of derris and pyrethrum powder applied at different times of the day. The prevailing weather conditions, which were partly cloudy, interfered. The results were as follow

Materials	Time applied	Mortality
		Percent
Pyrethrum (undiluted).....	2 p. m.	81
	6 p. m.	85.5
	6 a. m.	86
	10 a. m.	59
Derris (undiluted).....	2 p. m.	69
	6 p. m.	51
	6 a. m.	67.5
	10 a. m.	65
Derris and tobacco (1-3).....	6 p. m.	53.5

While pyrethrum completed its effectiveness at the end of the 24-hour period, many of the worms remaining on the derris treated plots ranged from slightly to severely affected. Incidentally, a shower of rain fell about 6 a.m. on the last counting day, and it was noted in the derris plots that many of the worms were killed very quickly afterwards, indicating that the presence of moisture may increase effectiveness.

Summary and discussion of results on control experiments. Since the results presented cover only one season's work, definite conclusions are not warranted at this time. However, comments concerning comparative effectiveness of materials and other points of interest are made at this time on the basis of the data available.

Derris dust: When used undiluted or mixed with equal parts of finely ground tobacco dust or sulphur, ground derris root proved to be more toxic to each of the three species studied than the other materials tested. It apparently has a residual action which pyrethrum dust does not have. Plants dusted with derris appear to be more thrifty and freer from thrips than those dusted with other materials. The data thus far obtained indicated that dosages of 3 to 6 pounds (mixed with equal amounts of tobacco dust) per acre per application, applied under favorable conditions, will effectively control the cabbage looper, the common cabbage worm, and the diamond-back larvae. As conflicting results were obtained with reference to the most favorable time of application, further tests should be made to determine whether or not the time of day has any influence on control. Derris caused certain discomforts in handling, including slight tickling and irritation of the respiratory organs and, if breathed for a long period, slight nausea. No plant injury occurred.

Pyrethrum: Pyrethrum powder, used undiluted or mixed with equal parts of finely-ground tobacco and certain other combinations of diluents, proved to be next in toxicity to the derris powder, being almost as effective. It was also more effective in reducing populations than the arsenicals used. It was decidedly more effective on the younger stages of the larvae. Dosages of from 3 to 6 pounds of high-grade pyrethrum powder, (mixed with equal amounts of tobacco dust) per acre per application will effectively control the species of cabbage worms studied. Pyrethrum kills rather rapidly as compared with derris, but lacks the residual action. Inferior results were obtained with pyrethrum when applied early in the morning as compared with applications made late in the afternoon or evening. Although slightly irritating, it caused no particular discomfort to those making applications. No plant injury resulted.

Hellebore: This material is considerably inferior to pyrethrum and derris, although it compares fairly favorably with the arsenicals used. It is not possible to obtain an analysis of hellebore that will enable the use of material of constant strength. Hellebore dust caused severe irritation to the operator, necessitating in some cases the use of a respirator.

Arsenicals: As indicated previously, satisfactory control was not obtained by the use of arsenicals in these tests in any of the places in which they were used. At Baton Rouge lead arsenate and Paris green appeared to be superior to calcium arsenate. At Chadbourn calcium arsenate was superior to lead arsenate and inferior to Paris green.

Tobacco dust was a more satisfactory diluent than was sulphur. All of the nonarsenicals were greatly improved in dusting quality by the addition of the tobacco dust, as they do not have particularly good dusting characteristics. It is quite likely that further work will indicate that pyrethrum and derris can be used at higher dilutions with satisfactory control.

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